same. The number of students last year was 1171. If any one figure can be taken as a measure of the efficiency of a well-conducted school, it is the ratio of the total number of students to the number of instructors in actual service. In the case of the Institute of Technology, without counting lecturers, there is one instructor to every eight or nine students—one of the very highest ratios in the United States.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, December 8, 1898.—"Mathematical Contributions to the Theory of Evolution. VI. Reproductive or Genetic Selection. Part I. Theoretical." By Karl Pearson. "Part II. On the Inheritance of Fertility in Man." By Karl Pearson and Alice Lee. "Part III. On the Inheritance of Fecundity in Thoroughbred Race-horses." By Karl Pearson, with the assistance of Leslie Bramley-Moore.

The object of this memoir is twofold: first, to develop the theory of reproductive or genetic selection[1] on the assumption that fertility and fecundity may be heritable characters; and, secondly, to demonstrate from two concrete examples that fertility and fecundity actually are inherited.

The problem of whether fertility is or is not inherited, is one of very far reaching consequences. It stands on an entirely different footing to the question of inheritance of other characters. That any other organ or character is inherited, provided that inheritance is not stronger for one value of the organ or character than another, is perfectly consistent with the organic stability of a community of individuals. That fertility should be inherited is not consistent with the stability of such a community, unless there be a differential death-rate, more intense for the offspring of the more fertile, *i.e.* unless natural selection or other factor of evolution holds reproductive selection in check. The inheritance of fertility and the correlation of fertility with other characters are principles momentous in their results for our conceptions of evolution; they mark a continual tendency in a race to progress in a definite direction, unless equilibrium be maintained by any other equipollent factors, exhibited in the form of a differential death-rate on the most fertile. Such a differential death-rate probably exists in wild life, at any rate until the environment changes and the equilibrium between natural and reproductive selection is upset. How far it exists in civilised communities of mankind is another and more difficult problem, which I have partially dealt with elsewhere. At any rate it becomes necessary for the biologist either to affirm or deny the two principles stated above. If he affirms them, then he must look upon all races as tending to progress in definite directions—not necessarily one, but possibly several different directions, according to the characters with which fertility may be correlated—the moment natural selection is suspended; the organism carries in itself, in virtue of the laws of inheritance and the correlation of its characters, a tendency to progressive change. If, on the other hand, the biologist denies these principles, then he must be prepared to meet the weight of evidence in favour of the inheritance of fertility and fecundity contained in Parts II. and III. of the present memoir.

The theory discussed in Part I. opens with the proof that if fertility be a function of any physical characters which are themselves inherited according to the law of ancestral heredity, then it must itself be inherited according to that law. As fertility would certainly appear to be associated with physique, we have thus an *à priori* argument in favour of its inheritance.

Further points dealt with are the influence of "record-making" on apparent fertility and fecundity. The fertility of mothers is always found to be more and their variability less than the fertility and variability of daughters. Accordingly from the apparent fertility and variability of the record the actual values in each generation must be deduced.

Methods are developed for finding correlation coefficients from the means of "arrays." These methods are of considerable importance, for they enable us to ascertain the correlation between a latent character in one sex and a patent character in another, or between characters latent in two individuals. Thus, it is shown that the correlation between the brood-mare's fecundity latent in two related stallions can be deduced from the correlation between the mean fecundities of their two arrays of daughters. In this way a numerical estimate can be formed of the inheritance of latent characters.

The effect of a mixture of correlated and uncorrelated material on correlation and variation is next investigated, and it is shown that the former is more seriously affected than the latter. Incidently the problem of the mixture of heterogeneous materials uncorrelated in themselves is investigated, and it is shown that a correlation will result in the mixture. This *spurious* correlation is of some importance for the question of mixtures of classes in fertility problems, but it is also significant of the general danger of heterogeneity in bio-statistical investigations, and further indicative of the possibility of creating correlation between two characters by breeding between small heterogeneous groups in which this correlation is zero.

Part II. of the memoir deals with the inheritance of fertility in man. It is first shown by large numbers that fertility is undoubtedly inherited from mother to daughter, but that if we include all types of marriages the inheritance is largely screened by other factors. An attempt is made to remove one by one these factors, and the more stringently this is done the more nearly the regression of daughter on mother moves up towards he value required by the law of ancestral heredity.

The inheritance of fertility from father to son is then considered; this is really rather an inheritance of sterility or tendency to sterility, for the full fecundity of a man is not usually exhibited in monogamic union. It is rather a problem of whether his fecundity lasts as long as his wife's. We find definite inheritance from father to son of this sterile tendency, although for the reason just given it falls below that indicated by the law of ancestral heredity.

Lastly, the inheritance of fertility in the woman through the male line is dealt with, and it is shown that a woman's fertility is as highly correlated with that of her paternal as with that of her maternal grandmother. In other words the latent character, fertility in the woman, is transmitted through the male line, and with an intensity which approximates to that required by the law of ancestral heredity.

Part III. of the memoir contains the results of a somewhat laborious investigation into the fecundity of brood-mares, which has been a number of years in progress.

(1) Fecundity in the brood-mare is inherited from dam to mare.

(2) It is also inherited from grand-dam to mare through the dam.

In both these cases the intensity is much less than would be indicated by the law of ancestral heredity, but the divergence is not such that it could not be accounted for by a percentage of fictitious values such as the peculiar conditions of horse-breeding warrant us in considering probable.

(3) The latent quality, fecundity in the brood-mare, is inherited through the sire; this is shown not only by the correlation between half-sisters, but by actual determination of the correlation between the latent character in the sire and the patent character in the daughter.

(4) The latent quality, fecundity in the brood-mare, is inherited by the stallion from his sire. This is shown not only by the fecundity correlation between a sire's daughters and his half-sisters, but also by a direct determination of the correlation between the latent quality in the stallion and in his sire.

In both these cases of latent qualities the law of inheritance approaches much more closely to that required by the Galtonian rule.

Parts II. and III. accordingly force us to the conclusion that fertility is inherited in man and fecundity in the horse, and therefore probably that both these characters are inherited in all types of life. It would indeed be difficult to explain by evolution the great variety of values these characters take in allied species, if this were not true. That they are inherited according to the Galtonian rule seems to us very probable, but not demonstrated to certainty. It is a reasonable hypothesis until more data are forthcoming.

PARIS.

Academy of Sciences, December 26, 1898.—M. Wolf in the chair.—Some peculiarities of the elasticity of muscle explained by comparison of the case of muscular substance in action with that of inert materials, by M. A. Chauveau. An experimental

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[1] I have retained the term "reproductive" selection here, although objection has been raised to it, because it has been used in the earlier memoirs of this series. Mr. Galton has kindly provided me with "genetic" and "proliferal" selection. The term is used to describe selection of predominant types owing to the different grades of reproductivity being inherited, and without the influence of a differential death-rate.

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comparison of the elasticity of vulcanised india-rubber with that of muscle in a state of physiological work. The results are expressed graphically in a series of six diagrams.—Histology of the skin: the epidermal fat of birds, by M. L. Ranvier. A study of the cause of the difference between the epidermal wax of mammals and the fatty material obtained from the feet of birds. A tangential section from the scaly portion of a chicken's foot, stained with osmic acid, showed that the epidermal cells are charged with liquid oily drops.—On a photograph of the nebula of Baleine obtained at the Observatory of Toulouse, by MM. Bailland and Bourget. The spiral in the nucleus, first described by Lord Rosse, is very clearly marked in the photograph.—Observations and elements of the new Chase comet, by M. G. Fayet.—On differential systems the integration of which can be reduced to that of total differential equations, by M. Riquier.—On differential equations of the first order, by M. Armand Cahen.—On linear total differential equations, by M. Alf. Guldberg. — On the velocity of sound in dry air at 0° C., by M. A. Leduc. A reply to the criticisms of M. Violle.—Influence of pressure on the initial polarisation capacity, by M. A. Chassy. Polarisation cells containing electrodes of various metals, as well as platinum black, were submitted to pressures ranging from 1 to 2000 atmospheres, without any appreciable change in the value of the polarisation capacity being noticeable. It is hence concluded that the phenomenon of initial polarisation does not correspond to an electrolytic decomposition into gaseous elements.—Radioconductors, with gold and platinum filings, by M. Édouard Branly. The use of gold powder for the preparation of tubes used in the detection of Hertzian waves has been negatived by Prof. Oliver Lodge; but the author finds, on the contrary, that although the successful use of tubes of this metal requires more delicate handling than other powders, this objection is more than counterbalanced by the extreme sensitiveness of the apparatus.—On a solution of the problem of multicommunication in telegraphy by the use of electric oscillations, by M. Albert Turpain. Having given several stations, A, B, C, . . . L, N, distributed along a single wire A N, the arrangement described permits of the simultaneous telegraphic or telephonic transmission of message between any pair of stations.—Remarks on the simple kathode rays, by M. H. Deslandres. A discussion of the views of M. Goldstein, and of his claims to priority on this subject.—On a new strongly radio-active substance contained in pitchblende, by M. and Mme. P. Curie and M. G. Bémon (see p. 232).—On the spectrum of a new radio-active substance, by M. Eug. Demarcay.—Researches on the separation and estimation of the halogen elements in their combinations with silver, by M. H. Baubigny. The mixed halogen silver salts are treated in the moist state with sulphuric acid and potassium bichromate at 90°-95° C. Under these conditions the iodide is quantitatively converted into iodate, and the chlorine and bromine set free. The test analyses are very satisfactory.—Action of oxidising agents upon some fatty and aromatic amines, by MM. Œchsner de Coninck and A. Combe. In presence of energetic oxidising agents the fatty amines are gradually decomposed, giving CO_2 and N_2. Under the same conditions the aromatic amines give colouring matters which are slowly decomposed with evolution of CO_2.—Thermal study of normal propylmalonic acid. Heat of formation of the solid potassium salt, by M. G. Massol.—On the oxidation products of oxygluconic acid, by M. Léon Boutroux. Oxidation with nitric acid gave racemic, trioxyglutaric, glyoxylic, and dioxybutyric acids.—The anti-virulent power of the serum of man and animals immunised against vaccinal or variolic infection, by MM. Béclère, Chambon, Ménard, and Jousset.—On an example of *Dasypeltis scabra*, by M. Léon Vaillant.—Fall of fossilised crustacean ostracods observed at Oullins, near Lyons, September 24, by M. Lortet.—Contribution to the study of the morphology of the Craspedomonadeæ, by M. J. Kunstler.—On the presence of *Rinus sylvestris* in the quaternian gravels near Troyes, by M. P. Fliche. The remains found consist of the wood, roots, branches, bark, and cones, the latter being especially well preserved. The fossils do not occur in the base of the gravel, but are very abundant in the middle region. —On the discovery of graptoliths in the conglomerates of the vosgian grit in the neighbourhood of Raon-l'Étape, by M. Bleicher.—Appearance of the bear in the Miocene period, by M. Claude Gaillard.—On the folding of strata near Belledone, by M. P. Lory.—On the foldings of the Cretaceous strata of the Aquitaine basin, by M. Ph. Glangeaud.—On the origin of the iron ore of the Neocomian at Bray, by the superficial alteration of iron carbonate, and on the importance and continuity in depth of the carbonated ore, by M. W. de Mercey.—Observations by M. de Lapparent on the preceding paper.—On the existence near Corinth of lherzolites identical with those found in the Pyrenees, by M. A. Lacroix.—On a new law relating to the grouping of crystals, by M. Fr. Wallerant.—New researches on a means of preventing oak wood from being worm-eaten, by M. Émile Mer.

DIARY OF SOCIETIES.

TUESDAY, JANUARY 10.

INSTITUTION OF CIVIL ENGINEERS, at 8.—High-Speed Engines: John Handsley Dales.

ANTHROPOLOGICAL INSTITUTE, at 8.30.—On Micronesian Weapons, Dress, Implements, &c.: F. W. Christian.

WEDNESDAY, JANUARY 11.

SOCIETY OF ARTS, at 7.—Juvenile Lecture: Some Ways in which Animals Breathe: Prof. F. Jeffrey Bell.

THURSDAY, JANUARY 12.

MATHEMATICAL SOCIETY, at 8.—On a Determinant each of whose Elements is the prduct of *k* Factors: Prof. W. H. Metzler.—Properties of Hyper-space, in relation to Systems of Forces, the Kinematics of Rigid Bodies, and Clifford's Parallels: A. N. Whitehead.—A Simple Method of Factorising Large Composite Numbers of any unknown form: D. Biddle.—Zeroes of the Bessel Functions (second paper): H. M. Macdonald.

INSTITUTION OF ELECTRICAL ENGINEERS, at 8.

BOOKS and SERIALS RECEIVED.

BOOKS—Catalogue of the Lepidoptera Phalænæ in the British Museum: Sir G. F. Hampson (London).—Plates to ditto.—The Brain Machine: Dr. A. Wilson (Churchill).—Les Terres Rares: P. Truchot (Paris, Carré).—Advanced Inorganic Chemistry: Dr. G. H. Bailey (Clive).—The Principles of Stratigraphical Geology: J. E. Marr (Cambridge University Press).—Octonions: Prof. A. McAulay (Cambridge University Press).—Scientific Papers of Prof. P. G. Tait, Vol. i. (Cambridge University Press).—Spherical Trigonometry: W. W. Lane (Macmillan).—Introduction to the Theory of Analytic Functions; Profs. Harkness and Morley (Macmillan).

SERIALS.—Longman's Magazine, January (Longmans).—Agricultural Gazette of New South Wales, October (Sydney).—National Review, January (Arnold).—Bulletin of the American Mathematical Society, December (N.Y., Macmillan).—Physical Review, September-October (Macmillan).—Humanitarian, January (Duckworth).—Contemporary Review, January (Isbister).—Journal of the Royal Horticultural Society, January (117 Victoria Street).—Journal of the Royal Microscopical Society, December (Williams).—Journal of Experimental Medicine, Vol. 3, No. 6 Appleton).—American Naturalist, December (Ginn).—Brain, Part 83 Macmillan).

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